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ABSTRACT

This conference report explores microelectronic technology, its effect on educational methods and objectives, and its implications for educator responsibilities. Two main areas were considered: the significance of the likely impact of the large scale introduction of microprocessors and microelectronics on commercial and industrial processes, the likely changes in society, and opportunities and dangers for the future: and the implications of the effect of microprocessors and microelectronics on the educational process with particular reference to content, attitudes, skills, concepts, and educational methods. A state of the art address opened the meeting, followed by presentations on the relationship of these technologies to teaching methods, and on their effects upon publishing. Discussion groups considered the effects on school curricula, educational responsibilities for an employment environment affected by microtechnology, and the potential of microprocessors for independent and interactive learning. (RAA)

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EDUCATIONAL IMPLICATIONS

OF

MICROELECTRONICS AND MICROPROCESSORS

A one day Conference

for those involved in

teacher training and in industry

held at the

University of Bath

on

Wednesday 26 September 1979

Edited by N.D.C. Harris

Director, Science and Technology Education Centre

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INTRODUCTION

The purposes of the Conference were to consider two main areas:

(i) the significance of the effect likely to occur in commercial and industrial processes as a result of the large-scale introduction of microprocessors and microelectronics, the likely changes in society, the opportunities and dangers for the future.

(ii) the implications of the effect of microprocessors and microelectronics on the educational process with particular reference to content, attitudes, skills, concepts and educational methods.

The Conference was attended by initial teacher trainers, practising teachers, representatives from industry, commerce, local authorities, trade unions and government departments.

The Conference was part of a process of activities and involvement organised by the Science and Technology Education Centre on behalf of the Frontier Group on Strategies for Change in a Technological Society. The activities are carried out in association with other SATRO's (Science and Technology Regional Organisations) in the West of England.

The aim of the Frontier Group is to develop ideas for Strategies for Change. The membership is made up of persons from commerce, churches, education, government departments, industry and trade unions. The membership is not fixed and the Frontier Group welcomes anyone who is interested in its activities and who is prepared to attend the meetings.

Meetings are held three times each year with an initial presentation of ideas by an individual or a group of people. Persons outside the Frontier Group will be invited to this presentation. After a refreshment interval the Frontier Group will meet to consider the implications and what action should be taken if any.

The Frontier Group is associated with the University of Bath Science and Technology Education Centre. The Director of the Centre is the secretary

and convener of the Frontier Group. The Frontier Group relates to all the SATRO's (Science and Technology Regional Organisations) in the West of England.

The Frontier Group initiates a Conference theme each year. The Conference organising committee is made up from a group including some members of the Frontier Group. The Conference organising committee then continues to disseminate the ideas of the Conference in the region (primarily Avon, Gloucestershire, Somerset and Wiltshire) through further activities particularly involving education, industry, commerce and government departments. The activities will last for three to five years including evaluation.

NEW TRICKS, NEW TRAINERS

Professor W. Gosling
Head of School of Electrical Engineering
University of Bath

Since the famous BBC Horizon programme on the microelectronics revolution and all the follow-up programmes that ensued, since all the discussion in the press and pubs, it is not perhaps necessary any more to say that in microelectronics we have a technclogical innovation the like of which has never been seen before.

It is more than just one technological trick among others, because it opens up a whole new realm in a way that the others do not. By this new means we can now fabricate devices, machines if you like to call them that, which are of more than biological complexity yet absurdly cheap to make. We, for example, now have the opportunity to create micro-computers of great power at a cost so low that we can afford to use them to control the engine of a car, a process in industry, a washing machine in the home, or a robot in the factory or on the battlefield, wherever we can get even the most marginal advantage by doing so. It is thus a technology which, in a sense, penetrates all others, making things possible for them which otherwise would not be. This gives it a kind of technological primacy which they do not possess, since it is the prop and stay for all of them. Hardly any aspect of manufacturing industry, from aircraft to pharmaceuticals or wellington boots to whisky, will not be affected, either in change of the product or change in methods of manufacture or quality control. The service industries will be no less profoundly altered. Even the learned professions are already beginning to feel the impact. By comparison, space technology and nuclear power are second rate sideshows.

We are already becoming familiar with microphotographs of these remarkable new devices, at once intriguing, alien and sometimes beautiful in their complexity. The computer on a chip of silicon only a few tenths of an inch square, as powerful as a roomful of electronics from a quarter of a century ago, yet capable of passing through the eye of a needle - all of this is now almost a cliché.

To go deeply into the technology of their manufacture would be time-consuming

and out of place on this occasion. It is enough to say that they are fabricated hundreds or thousands at a time, these microcircuits, on thin slices of monocrystalline silicon, one of the world's most plentiful elements. After a lengthy series of chemical processes, the finished slices are cut into the individual chips by multigang diamond saws. We can form an impression of the magnitude of the change that we face by looking at the way the parameters of those chips are changing with the passage of the years.

The fundamental building block out of which most of the circuits are constructed is called a gate: it is a structure which can perform a single logical decision. The number of gates per chip is therefore a useful measure of the complexity of circuits which we can handle. At present the figure is around 100,000 gates per chip, but without doubt this will rise to a million by the early eighties, and competent authorities expect ten million by the end of the decade, all on a chip less than a centimetre square. We already surpass the packing density of nerve cells in the brain, and may do so by more than one hundred fold before 1990.

As they get more complex they also operate faster. The time in which a gate operates to make its logical decision is measured in a very special unit - the nanosecond. This inconceivably fleeting interval of time, one thousandth of a millionth of a second, is about the time it takes light to travel one foot. Our microcircuits broke the nanosecond time barrier some time ago - the semiconductor gates are a million times faster in operation than the nerve cells of the brain. Yet at the same time, as the complexity and speed of our circuits has leapt ahead, costs have dropped no less quickly. Where once we counted the cost of a gate in pounds, and later in pence, today we think of small fractions of a penny per gate.

To describe all these things in cold and prosaic words is my job on this occasion - little imagination is needed to realise that the social impact of a technological change on this scale is likely to be comparable with that of the invention of the wheel. Even this is easy enough to say, but so shocking that its implications take a while to sink in. What it comes down to is this: we are living in the age when the machines began to think. Using microelectronics, and operating at a greater than biological level of complexity yet absurdly low cost, we can equip our machines to perceive, calculate, make logical decisions and act upon their conclusions. They have senses and memory.

If we sometimes hesitate to ascribe the power of thought to them, perhaps this is because we recognise that these electronic brains, which we have created, do not think at all as we do. Their virtues are coincident with our weaknesses and we are strong where they fumble. They think faster than us, do not forget as we do, and tolerate endless repetition which we would find numbingly, unendurably boring. Yet they cannot create, originate, invent as we can, do not know pleasure, cannot fall in love or philosophise on their mortality. They are motiveless.

We have not created an intelligence to rival ours, as some suppose, but another brand of intelligence altogether, which is as different from ours as metal and crystal is from flesh and blood. Yet the intelligence so created is exactly right for the needs of industry and agriculture. If we can build a robot around a microcomputer brain, we do not need to require human beings to play a robot-like role. Thus some of the most unattractive jobs in our industrial economy can be eliminated.

There is interminable discussion at the moment about technology-produced unemployment. For myself, I have no wish to make light of the social problems facing us as we enter this new age of the thinking machines. It is always painful to live in an epoch of transition, even if it can also be at the same time exciting and enjoyable. One of the functions of collective social action at such a time is to try to minimise the pain - in part, that is why we are here.

However that may be, the difficulties of making a transformation to the future ought not to blind us to the fact that the technology now coming is potentially the most liberating in all human history. When people were needed to tend and control the insensate machines of the first industrial revolution, they were a key element in the then systems of production. The temptation to exploit them was almost irresistable, simply because of the great wealth such exploitation could bring. The electronic engineers are bringing that to an end, for when our technological revolution has run to its close, manufacturing industry and agriculture alike will be robot based, and if - which God forbid - we fight wars, it will be robot armies which fight them.

Thus we can confidently expect that what we are doing in electronics will re-make the world. Political and social institutions, the arts, everyday life, all will be changed. The future and the past will be strangers to each other. What the engineers have put their hand to will set the new patterns and styles for the world of our future. This process of change can pass our country by, leaving us

to be dragged in its wake, unable to determine our own destiny, or we can learn to swim in it, be at home, make it bear us where we will. That is the choice we have to make, and the decisions that we arrive at now about education are part of the process of choosing.

For some time, indeed a generation and more, the feeling has been growing that something is wrong in British engineering. There was a very poor return in industrial growth for the substantial national post-war investment in higher education. Throughout the post-expansion period in the Universities and Polytechnics there were empty science and engineering places. The young people of the late fifties through to the early seventies exhibited a continuing and stable tendency to read anything but engineering for their degrees. From the time of the flower people through to the age of the campus radicals, this was the era when the social science and arts faculties blossomed unchecked. After the Robbins report, the conviction was almost universally held that the young must study whatever they in their wisdom chose. National need was held to be too difficult to measure for there to be any way in which it could be reflected in a policy for undergraduate recruitment. So there were empty places in the Engineering schools, and entry standards sagged ever lower.

At the same time engineering graduates chose either to emigrate or seek posts in Government service or education rather than go into industry. What few our industry got - and perhaps they were not the cream - gave their employers little satisfaction, or so it often seemed. A growing criticism of the quality of the graduates and content of engineering curricula was heard from industrialists. Few seemed aware that despite the vast cost of our higher educational system, we were actually spending less per graduate on engineering education than was any other developed country.

No doubt the British academic did his best in the three years of the BSc, compared with the five or six years thought necessary to produce a competent engineer in many other countries, but he could not work miracles. Indeed it was not always clear that the academics themselves were, as they should be, among the ablest of their profession. The Universities and Polytechnics insisted on paying exactly the same salaries to lecturers in engineering, who if they were able could invariably do better in industry or government service, as they also paid to philosophers or historians, who were quite unemployable in their profession outside Academe. This was a part of the price of opting for our traditional broad universities, with the scientist on tap (as the comfortable

saying then was) but not on top. We had rejected both the sharp salary differentials between faculties typical of American universities, and the quite separate development of technology epitomised by the great Continental technical universities.

We might have accepted that modern technological societies create wealth principally by industry, which prospers only if certain conditions are met. The notion that one of those conditions is a supply of appropriately trained and educated engineers and technicians would perhaps also have been conceded. However, that to meet this condition would be costly in money and, more difficult, would involve the creation of new and prestigious institutions was accepted neither by the political Left, who rejected the implication of elitism, nor by the Right, who feared an erosion of traditional values and could not rid themselves of the establishment conviction that the elite role should be reserved for the overwhelmingly Arts-oriented Cambridge and Oxford, the latter with fourteen professors of history and one of engineering. In the end the efforts towards special technological institutions all failed: the CATs lapped at the saucer of university status, the weird SISTERs barely survived their conception, and the polytechnics, most pathetic of all, were reduced to promoting themselves on the still unproven assertion that they could do what the universities did, but cheaper. As Ezra Pound wrote:

> Leucis, who intended a Grand Passion,
> Ends with a willingness-to-oblige.

So triumphed the seemingly irremediable association in the English Establishment mind between technology, sweaty overalls, and egg-and-chips high teas. Our condition is bad, some would say critical, and perhaps we have come to the situation of a man who has sunk already so far into the swamp that he knows that there is no hope for him, gives up his struggles and composes himself for his end. Perhaps, but I do not think so.

Recently the Government set up the Finniston Committee of Enquiry into the Engineering Profession. Seen in the perspective of our present situation, to demand the whole blueprint for our salvation of that Committee is to ask more, far more, than they could possibly be expected to give. Even so their establishment and continued deliberations, likely, so we hear, to have a very positive outcome in the near future, is an indication that we battle on, not yet having succumbed to our fears. It is a sign of hope, and one among others, for there is energy yet in our country, and we are stirring. As always,

the young are showing us the way, with the swing to hard science and engineering in University and Polytechnic recruitment which is becoming ever more manifest. This is the best of news for the future, and we must not fail to provide these admirable young people with the educational opportunities which they are now seeking, for our country's sake.

Those who exercise power in our land need not hope that they can create an engineering profession adequate to the needs of our so rapidly evolving society at trifling cost and without substantial re-making of the customary fabric of British life. For our industries to be effective, whether in manufacturing, the services, or even agriculture, we need, and urgently, to secure the supply of four categories of people, as the Institution of Electrical Engineers explained in its submission to the Finniston Committee.

At the top we need an elite corps of engineers, particularly electronic engineers, who will be as able, perhaps abler, than any others in the world. They will not be numerous, but to induce the most talented people to seek such a life they must be given the only inducements which have ever been known to work, namely honour, prestige and wealth. In this connection, the recent establishment of the Fellowship of Engineering demonstrates a welcome willingness - at last - to give acclaim to distinguished engineers.

A little less talented but much more numerous than the "first division" will have to be a good "second division" of professional engineers, who will carry the major part of the work, supported by the next two echelons, the technician engineers and the technicians.

All four will need appropriate educational provision and suitable training. We have shirked this in Britain, failing to provide the top level altogether, doing the second with all too little regard for real industrial needs, and hoping that the less successful from the second level may suffice to provide the third. Our technician training, good in its day, has been allowed to atrophy and egalitarian social policies have eroded the rewards of education and training at all levels.

Should you be on the Left wing of politics, then for you egalitarianism constitutes a primary consideration. The emergence of highly rewarded elite groups is considered socially undesirable in itself. If we are to have outstanding engineers, in this view, they must be motivated by altruism or intellectual enthusiasm. If that will not work, and all the historical

evidence screams that it will not, then the true egalitarian will argue, even with some reluctance, that a poor but equal society is better than a wealthy unequal one. It is as if the sufferings of the poor in nineteenth century capitalism, which were indeed an accusation against humanity, have been so traumatic in their psychological consequences and have so scarred the liberal imagination that the possibility that some degree of social inequality is unavoidable for effective social function cannot be entertained.

One of the more engaging fantasies that Karl Marx allowed himself was that specialisation of labour - expertise - would one day fade away. It has not proved to be so. The day has not dawned, and will never dawn, when one can drive a locomotive today, do a little brain surgery tomorrow, and be an electronics engineer on the day after. Work, in our society, is becoming more differentiated, not less, and expertise more intense. For the more taxing, difficult and important specialisms sufficient rewards, tangible and intangible, must be forthcoming to elicit the number and quality of recruits that are needed. The alternative is a progressive national impoverishment and ultimately the egalitarianism of the poor house.

On the political right, by contrast, the excuse for inaction and toleration of the present unsatisfactory state is that if society needs these things the working of the market economy will produce them. However, we are talking about the human stock of our society and that is slow to change. If you fail to reward engineers, relative to the levels which would produce a stable supply acceptable in quality and number, or if you educate and train them inadequately relative to the technology of the society in which they will operate, you may have thirty years before your folly becomes manifest.

Equally, should you learn the error of your ways, it could be decades before the contrary policy generates enough additional wealth to become self-sustaining through market forces. The timescales are too long for entrepreneurs, perhaps - and this is our great danger - for politicians.

In England our national policy towards engineering was manifestly wrong by the second half of the nineteenth century, as Playfair pointed out at the time. Over-confident of our dominance in industrial matters, which a generation earlier had been absolute, we did not develop the educational or social institutions to bring on a class of highly respected professional engineers comparable to that which developed in Germany, France and other European countries. For yet another generation thereafter we went on having our triumphs,

but it was an Indian summer, and now we feel the frost.

Perhaps no disaster which can befall a people is sadder than to be the centre of an empire based on trade. The greatest such empire that the world has ever seen - the Arab empire which extended from France to Indonesia - on its collapse reduced the Arab people to a pitiable state from which only in our own time are they beginning to recover. Similarly the British empire was a disaster for us, if a lesser one by virtue of its shorter duration. The ruling people of an empire learn to live not by making things which sell in a free market, but by the arts of diplomacy and government, by talk. If they make things at all they are likely to be goods which only those will buy who must. And if it all depends on trade, then woe betide, for the terms and technology of trade are as changeable as the face of the sea.

This curse was laid on us. It gave us, for a time, great wealth, but it left us, in the end, with all too many obsolescent industries, grown fat and slow on captive markets, no properly based system of engineering education, and the deeply held conviction that law, politics and government service were the proper professions for the ablest. To the English ruling class it was a natural transition from being the squirearchy of a rural England to performing the same function on a world scale for the Empire. It confirmed them in the belief that the proper education of a gentleman was one that fitted him for such a role. Today we are left with a situation in which we encourage, treat as prestigious and most highly reward talents and skills that cannot earn our living and bid fair to be our curse. Chesterton described the consequences:

> They have given us into the hand of new unhappy Lords,
> Lords without anger and honour, who dare not carry their swords,
> They fight by shuffling papers, they have bright dead alien eyes,
> They look at our labour and laughter as a tired man looks at flies.

What can not be done? First we have to realise that we are dealing with profound, but not irremediable, defects in our society which prejudice its long term viability. I may be thought over-optimistic for saying so, but I believe that this idea is ever more current and acceptable, and consequently it seems to me that this hurdle we have jumped. There is a danger that we have landed badly on the other side, and having become aware at last of the profundity of the problem we convince ourselves that it is beyond our real power to heal it. This I do not believe. Very recent history presents

many examples of societies apparently in the most severe, even terminal, crisis, which nevertheless speedily found the means to regenerate themselves - for example the United States in the depression of the thirties, or West Germany at the end of World War 2. If it is argued that our problem is, as I have hinted, one of prevailing and deeply held social attitudes and convictions, conceptions of human nature and life goals which are wrongly oriented for the world in which we have to live, but that these profound psycho-social factors are not mutable, I must disagree. First, such attitudes are not so old and well-established as some suppose, and secondly they cannot compare in irrelevancy, rigidity and universality with the internal social environment of Japan prior to the Meiji restoration, which, let us not forget, did not take place until well into the second half of the nineeteenth century. Within a generation Japan was able to challenge and defeat Imperial Russia, until then regarded as a major world power, and today, only a century on, Japan's industrial vigour terrifies the community of nations.

So let us be clear-eyed as to our condition, but not paralysed by the awfulness of it. Secondly, let us understand that we are totally committed to the Technological solution to our problems, to a degree from which it is wholly impossible to draw back. Actually this is not only true for England - it is as valid for the human race as a whole.

We began to differentiate ourselves from the other primates by our capacity to make weapons - we are hunting, the carnivorous ape, and we are the only one. Unequipped with fang or claw, it is with weapons that we became natural history's bloodiest and most effective predator. The evolution of weapons for hunting and war was our first technology and one which remains our obsession to this day. Our second was agriculture which we only achieved hundreds of generations later. There is nothing at all natural about it. From the spade to the plough, the breeding of draft animals and fat stocks, the evolution of crop plants; it is all a most fascinating technology, part mechanical and part biological, which we in this country have now carried as far as any people in the world. Every other technology that we have evolved - windmills, water power, steam, the internal combustion engine, flight, the computer - has been harnessed according to its usefulness, to this our second great technological preoccupation, and before long you will see the robots working our fields. Romantics who dream the impossible dream of returning to a simple peasant rural economy - a dream which the Khmer Rouge of Cambodia have recently acted out as an incredibly bloody nightmare - may believe that they are escaping from

technology: actually they are only returning to a rather more primitive form of it. There is no escape, for we cannot escape what we are, technology is the obsession of our species.

The challenge to us in the UK now is to learn again to deploy technology with the facility and virtuosity which once we showed but which has now, seemingly, deserted us. For the long term we require a thorough reconstruction of our whole society, but fortunately we do not have to tackle this problem head-on. A reconstruction of our educational system is a first high priority.

So far as schools are concerned we must try to depart, at long last, from a school system which regards learning as an essentially literary matter. The answer is not science teaching, valuable although that is. We teach science, still, in a way that makes it remote from most children's experience and consequently many children reject it. The recent suggestion that this might be countered by teaching the non-science (or even anti-science) students the history or philosophy of science would be a retrograde step, a further retreat towards the literary paradigm.

What we need is an injection of technology into the schools: happily this is already happening. We owe a great debt of gratitude to the craft teaching tradition, which in recent years has embraced high technology in a quite remarkable way. It has now become a platitude to say that much simple technology is readily accessible to a very wide spectrum of children, and this the craft teachers have proved to the hilt. More power to them! Children can understand how, say, an electric bell works who would struggle with quadratic equations, yet the former is far more relevant to the lives they live, and of course for some (but not all) it will lead on to mathematics in a real-use environment.

Let me emphasise that I am not now speaking only of the school education of potential engineers and scientists. I am arguing for a greater breadth of education for all our children. Maybe you find the suggestion of technological education as a means of breadth injection a strange and hard to handle concept. For many people breadth equates to humanities and literary studies: they do not perceive an education on that basis only as deformed. If that is your position, you have my sympathy. It is hard to break out of the intellectual presumptions of one's own education. Even so, it is necessary to make the effort, because we need not only better specialist education, but also an

educational system which helps our population at large better to live in the world which is their heritage.

We cannot afford to keep educating our children in such a way that they are alientated from the man-made environment in which they live. No child should leave school without some understanding, however sketchy, of how a greenhouse, or a car engine, a petrol refinery, a tape recorder, or a computer works. School science and mathematics is definitely not the way into this: by contrast useable technology is a more viable path into science. Nor is technology less intellectually challenging than science or literature or less sublime: that is a delusion which we must outgrow, learning not to overvalue the verbal relative to the visual.

Those concerned with present problems of youth employment are very well aware that for at least a proportion of children the school education that they receive leaves them frustrated and alienated. From both its style and its content, it evokes a deeply felt contempt for learning and things of the intellect, a hostility to all imposed authority, and an alienation from the ordinary world of work. Those with a penchant for the conspiracy theories of history would blame this on left-wing schoolteachers who, in their view, create the problems in society that they predict. If only things were that simple, but they are not. The problem is in fact caused by a teaching profession of all and any political persuasion genuinely doing their best, as they see it, for their students and about as conscientiously as most of us are in the pursuit of our vocations. What invalidates so much of what they do is a misplaced and mistaken conception of the proper role and aim of education in late twentieth century Britain, not only among the profession, but widely diffused in society at large. But the times, I believe, are a changing. In those changes the teaching profession, or some of its members, are playing a leading part. We must give them every encouragement, and above all not succumb to the very real temptation to blame their profession alone for what in truth is a very general soceity disorientation.

At the other levels of education, we hope that the Finniston Committee report will impel us all towards new patterns of technician and engineer education which we so desperately need. The will is there among the educators. Already new degree schemes are being devised for professional engineers. It is important that this should be done in the closest and most intimate collaboration with industry, which must play the major role in pointing out the goals towards which

engineering education ought to aim. New curricula, new courses cannot be evolved solely within the universities on the basis of self-generated criteria. Equally, industry must recognise that the academics too have their expertise: we know what can and cannot be taught by the methods available to us, how long it will take, and what standards are attainable in given circumstances. By working together much can be achieved, but only if society at large is prepared to accept that we cannot prepare technologists to a given level of competence significantly cheaper than the academics do in the countries which are our major competitors. Indeed we ought, from where we are now, to be seeking to surpass them, to leap-frog over their educational standards, and oblige them, in due course, to emulate us.

The German diploma-engineer training is often held up to us as an example that we should follow. Significantly, they are far from satisfied with it. Although it greatly surpasses what we do in the rigour and extent of the taught course, it is deficient in contact between the educational establishment and the industry it served. They look with interest, and even a tinge of envy, at our sandwich degrees, which give the student industrial experience actually during his undergraduate years. If we could combine that aspect of our system with their high intellectual content, we might point the way to the future. You may have read in the newspapers recently of the new extended co-operative M.Eng degree course now being launched at the University of Bath, and planned in conjunction with the GEC-Marconi Group: Britain's largest electronics company. This tries to do exactly what I have proposed, and is aimed at producing an electronic engineering elite group second to none in the world. We expect that higher A-level grades will be needed to get on this course than to read Arts at Oxford or medicine at Bart's. Modesty forbids that I should say more - I hope that you will forgive this much of a commercial.

We must have three or four very prestigious technological universities able to run these elite-level engineering courses. I would favour the curtailment or closing of Arts faculties at these institutions so that the large resources which must necessarily be put into them will not be misdirected. Their staffs must be paid at premium levels, as are those at Oxford and Cambridge. This will be hotly contested, painful to individuals, and divisive to my profession. It is also necessary.

The other universities and the polytechnics will continue to prepare the three,

or hopefully four year sandwich, degree engineers. The latter is advantageous not only because of the experience that the undergraduate has, but also because it forces closer liaison between the teaching centre and industry. Accreditation of engineering degree courses could also help to secure realism in course design - although it is a two-edged sword, and if used unintelligently, as in CNAA in its earlier days, could be a terrible brake on innovation and course development.

Education and training of technician engineers and technicians, properly the domain of the Polytechnics and Colleges of Technology (whatever name the latter may now go under), is as vital, and some would say more vital, than the professional formation of the engineers. Here too we must learn from our industrial competitors abroad: the Dutch do it very well. We must also reward the acquisition of these skills when the pay levels and working conditions in industry are determined. If erosion of differentials undermines the viability of our industry - as it has done - not even the interests of the lowest paid are served by such a policy.

It has pleased God to grant to Britain an inestimably precious gift. Not only do we have North Sea oil, which guarantees us for a generation from feeling the full consequences of our past folly, but with our coal deposits we actually command within our borders 40% of the total hydrocarbon fuel reserves of Western Europe. It is hard to see why we, of all peoples, should have been given this bounty, but its practical consequence is that we as a country have a valuable and appreciating resource. It is the capital with which we can rescue ourselves without the need for social violence, bloodshed or revolution from the consequences of being the first developed country in the world and the survivors of a lost empire. We are an ingenious, intelligent and hardworking people, marred only by our long established habit of pessimism and despair. We have also been, throughout our history, a very lucky people, and that luck has not deserted us yet.

> "It may be we shall rise the last, as Frenchmen rose the first,
> Our wrath come after Russia's wrath, and our wrath be the worst.
> It may be we are meant to mark, with our riot and our rest
> God's Scorn for all men governing. It may be beer is best.
> But we are the people of England; and we have not spoken yet.
> Smile at us, pay us, pass us. But do not quite forget."

REPORT ON DISCUSSION GROUPS FOLLOWING PROFESSOR GOSLING'S LECTURE

Q. How do the arts and social sciences figure in the link with technology?

A. Technology, the arts and social sciences have a happy relationship on this campus. I think, however, that the arts faculty may be curtailed in those universities that we intend to develop as our major centres of technology. This is unavoidable. I have no desire for a war between arts and social sciences and technology and hope they will not be in disagreement.

Q. Technology in secondary schools. How do you see technology as a school subject? Is it closely related to science teaching?

A. I do not believe that a knowledge of science is a necessary pre-requisite of understanding simple technology, indeed at this level I consider there to be a bigger gulf between the technologist and the science faculty than the technologist and the arts and social sciences. If we look at the role of education in society we must believe that there is an element of some sort of informing the young people who pass through it of our society's characteristics, traditions, including technological dimensions. Pupils should know how a television works etc. We must get this dimension into education early - even as early as infant schools, for example I foresee the possibility of computers in infant schools. As a result of this a number of pupils will later turn to science having been introduced early to technology.

Q. There is a considerable problem in recruiting youngsters of a high IQ level into the craft and engineering areas in schools.

A. You will not get high IQ children into technology areas unless the introduction of technology is started earlier. Children should be motivated in infancy. A level rquirements for entry into university courses are restrictive. There have to be certain course requirements. One problem in reforms of education is that we in this country have always looked for simplistic solutions but this is not possible. Solutions to our problems have to evolve and will take a long time to do so.

Q. America, Japan, etc. lead the way in technology because they spend so much time training specialists. What we need is specialist education

A. Our country can lead the way as we have done in the past, not just in education for engineering specialists but for all members of our population, which will be of a new pattern. For example, Denmark, from having been a very poor country, brought about great advances with regard to its agriculture, due largely to the effort to extend education among the population at large. All education was involved, not just a specialist elite. Let us have a less one-sided school education. We are at present behind in terms of specialist education - what we should do is leapfrog over this by improvements in general education.

Q. At secondary level we must follow a balanced curriculum. There is a whole range of subjects. One person will say we must have more modern languages for example. We cannot single out technology.

A. You have to make this judgement. If you think our society is foundering because of the lack of modern languages you must make your judgement accordingly, but for heaven's sake do not let us compromise - trying a little of this and a little of that. If we are going to get it wrong let us at least go down with the band playing and all flags flying.

Q. We cannot put one subject out in favour of another by debate. What we teach in schools must take into consideration what the cost will be. As a general rule, subjects relying on chalk and talk will get preference.

A. If we worked solely on the basis of cost effectiveness universities would teach nothing but Greek! We in the teaching profession must be a little wiser than our masters.

Q. There are already appropriate resources available within the system to cope with the needs of teaching technology such as certain schools, polytechnics and universities. We must endeavour to make a better use of the resources that we have to suit the needs of the people in our schools. The needs of the society as far as technology is concerned have charged very rapidly over the last ten years. Education in schools has not been able to change at the same rate. At what stage do you stop being broad and general and start to specialise in a

more positive way than we now do? We must say that school takes us so far and there are then places to specialise and continue to the next stage.

A. I do not regard technology at O and A level as important as technology in infancy. Regarding higher education and when to specialise - it works quite well as it is now. There has been a proposal to shift sixth form work into Colleges but if this were the normal pattern we would be slicing the top off our schools. This should be thought about carefully.

Q. Technology is going to bring about great changes in individual lives. We have to be educating people who will be able to cope with this. Regarding the argument for the need for a broad education and not a specialist education up to school leaving age - anything worthwhile in the educational sector comes through having good teachers in the schools more so than by having extra subjects in the curriculum. If we cream off our good scientists, technologists and craft tutors and put them into the specialist institutions (above school leaving age) this will leave the existing schools in a powerless situation.

A. You are right in pointing out that it is our human resources in the schools which will make or break us. I am talking about broadening education and putting technology in for the bulk of our population, which in the longer run must help.

Q. School children need a basic education only. This enables them at a later date to expand and specialise. A broader curriculum is not the answer. Numeracy and literacy are most important.

A. GEC Marconi approached me some time ago with analogous criticisms to those you have expressed but at the degree level. They even produced a little booklet advising what we should do in this respect. I suggested that we should get together and discuss it, and we have since spent eighteen months to two years doing so. This has resulted in something very positive: the evolution of a new degree course. One of the very interesting things to become obvious about our industrial partners was their ignorance about the practicalities of the processes of education. No doubt we do want numeracy and literacy as you argue, but this is not an easy problem to be solved by trivial changes. It is a profound failure which demands radical treatment. What I am saying is that children will learn their numeracy very much better if their understanding of the need for it is greater. People learn well when they need to.

Q. Why do we recruit so very few women into engineering in Britain?

A. This is an interesting question, particularly if we consider that in the USSR 40% of engineers are women. In Iraq there are more women than men going into engineering, but the reason for this is because the top 5% of pupils at what is the equivalent of our A level examinations read engineering, the second 5% read medicine, the next 5% pure science, and so on. However, this is a digression. I think that we teach science in schools in a particular way in this country (and indeed many other countries) which may not necessarily favour girls. I suspect that if we taught technology at a very early stage so that it was related to real artefacts around them, this would open the door for girls first into technology and thence into science. This would go some way towards remedying the problem that you mention. There are still those who would say that technology is not a suitable career for young ladies, and this view might take one or two generations to alter, but otherwise my recommendations could bring about some of these desirable changes.

Q. The main problem is not technological but human. Prestige, money and power should be given to people who have imaginative ideas of how to deal with the kind of world we are living in. Is it not true that the misery that industrial development led us to in many ways was a very great price to pay and many of us are trying to repair this by going 'back to the land' (albeit ineffectively). Is this not where our resources should go?

A. The development of better engineering education is essential to prevent economic decline. I cannot believe that progressive impoverishment will other than make it harder to solve our social problems. However, above all I wish to make a plea for broader types of education for all of our people. I do not look forward to a society ruled by engineers or philosophers, but instead, as I see it, we should continue to have a democratic society with a well informed electorate - fundamental to good government as we know it therefore is a well and widely educated populace.

Q. Do we not want a more imaginative education rather than edging around to one side to make a space for a bit of say mechanical engineering?

A. Of course. I think you have failed to grasp the point, but we have to accept the fact that we do not have a unity of purpose, we all have different

views. Perhaps we sometimes underestimate the importance of modest changes. A small change in a small corner can ripple through and produce enormous alterations.

Q. My concern is for the engineer. Some are the product of a very specialised training. They tend to be ill equipped on the human side and tend towards the introvert.

A. That the type of engineer you refer to is a disaster I agree. This is the kind of engineering education we do not want to promote. MIT (America) for all its faults was and is a great institution and one of the things it is great at is in requiring that engineers should have some education outside the narrowly scientific. I think that engineers who are really almost pure scientists are an extremely dangerous animal, both socially and even, in the end to the success of the economy.

Q. What about the lack of software in this chip revolution?

A. This is a real problem. Software is a collection of memories from within the machine that make it function in a particular way. At present these are being written by hand in a sort of curious cottage industry. At present if you try and use microprocessors you will spend more on the software than on the hardware. This has to be solved for the near future in two steps:

(i) Instead of writing a further piece of software from scratch every time we should assemble pieces of pre-existing software and edit.

(ii) Mechanise the editing job.

Q. Broadening of education is difficult because of the knowledge of the staff involved in teaching these children. One cannot go beyond one's expertise.

A. We have to recognise that we live in a world that is changing so rapidly that unless we are all prepared to continue educating ourselves we will not be able to do our jobs properly. There are very few people of scientific background in infant schools but this is not really necessary for technology teaching. The level I refer to is more one of taking things apart and putting things together again. There is something called Populist Technology all about us. Look on any

bookstall and you will find an abundance of literature such as 'Teach Yourself Computers', 'Home Electronics', some of these are intellectually extremely difficult. They are often read by people who are entirely self-taught, and there is an enormous amount of this Populist Technology: it is an unnoticed resource of our society. It was the amateur enthusiasts who really came to the fore as radio and radar experts during World War 11. They were self-taught. This is an important resource in our society which we should try harder to recognise and perhaps learn to exploit.

Q. It would seem to me that we will need our very best teachers in primary schools. At the moment it is almost impossible to change from industry into education.

A. We in universities have called people from industry in the past to give lectures to students. This was sometimes a miserable failure because the people who came from industry were totally incompetent lecturers. This idea of taking people from industry to teach is not necessarily the right one. In any event, industry will stick like glue to its specialist people and we might end up with the 'off cuts'.

Q. Convergent thinking is encouraged because perhaps it is easier to test.

A. Yes, this is true. Convergent thinking is rewarded rather than creative or divergent thinking in most educational establishments. I would like to see a radical change in examination systems but this is difficult. We have not found a satisfactory solution. In the universities there is a tendency to regard project work as a possible answer but this is not easy to assess or evaluate.

Q. Industry has been slow in taking up the concept of microelectronics and microprocessors. How will the worker be affected?

A. It is interesting to note how very forward looking many of the trade unions are in this context. When jobs are actually going to disappear you do naturally get a negative reaction from people, but the trade unions are, on the whole, taking a positive line, and I would think that the problem in British use of these techniques is not primarily the problem that you identify. I think it is more a failure of management than workers. There is a shortage of risk capital and risk nerve. We must increase the reward for taking risk or alternatively we might find some way of taking risks within the state

system. Of this last, however, I am not optimistic.

Q. How would you see the development of microelectronics in the West affecting the development of the third world people?

A. I think it will be a disaster for the third world. What we have produced is basically robots. They can work at low labour costs. (In the Turin Fiat factory the robots work at a cost of approximately 50p per hour). The third world has had two major assets - raw materials and cheap labour. But only for their raw materials will we need them in future, and this is a terrible situation. Economists have predicted that the natural development of the motor industry will be for it to cease to exist in the developed world and to move to, for example, Taiwan, where labour is cheaper. I suspect that now we have the robot this will not, after all, happen.

If we want to find an outlet for the idealism of the young, which we hear so much about, one of the things we should keep in mind is whether we are prepared to have a world consisting of an economic elite of nations getting richer while the poor get poorer. Interdependence between the developed and the under-developed world which has been growing since the last war, may be reversed, once it is generally perceived that we no longer need their cheap labour.

Q. Are service industries going to be affected by the new technology?

A. About 40% of our working population are engaged in manufacturing industry. I would be astonished if by the end of the century this had not fallen to below 10%. Service industries are more difficult to assess. One must accept that there will be very major changes before the end of the Century. Clerical and secretarial work, communications and bureaucracies will all be depleted of people, unless natural trends are artificially restrained.

METHODS OF LEARNING
POTENTIAL OF MICROPROCESSORS AND MICROELECTRONICS FOR INDEPENDENT AND INTERACTIVE LEARNING

Philip Waterhouse
Director
Avon Resources for Learning and Development Unit

My list of computer possibilities for learning is a conventional one.

The role of the computer as a tutor is well-established. The machine, infinitely patient, offers routine drills and practice, and programmed learning, relieving the teacher of tasks which he may regard as tedious and worthy of delegation to a sub-professional or to a machine.

The possibilities of inter-active learning with a computer are exciting. Students of all ages have already discovered the joy and the effectiveness of simulations and games in learning; the computer can be an additional tool of immense power.

Problem solving implies a novel situation for the student; he has the necessary knowledge or skills, but needs to develop a strategy or a sequence which will get him to his desired goal.

The possibilities of creative activities aided by computers are very real, so that even quite young learners can sketch, animate and compose.

Computer managed learning offers a hope of relief from the tedium of marking, record keeping and test validation, and offers too the assistance of routine decisions and the generation of learning materials.

I shall call this the view from Olympus, because as far as the Primary and Secondary schools of the country are concerned it remains but a vision. I shall contrast it therefore with the view from Hades.

There has been much research, both in this country and in America, based on classroom observation. The researchers have reported a dismal picture on the whole:- a restricted range of methods and styles; few attempts to use systematic patterns of logical development; a marked concentration on the lowest levels of thinking; much rote learning; a dull, routine, and often

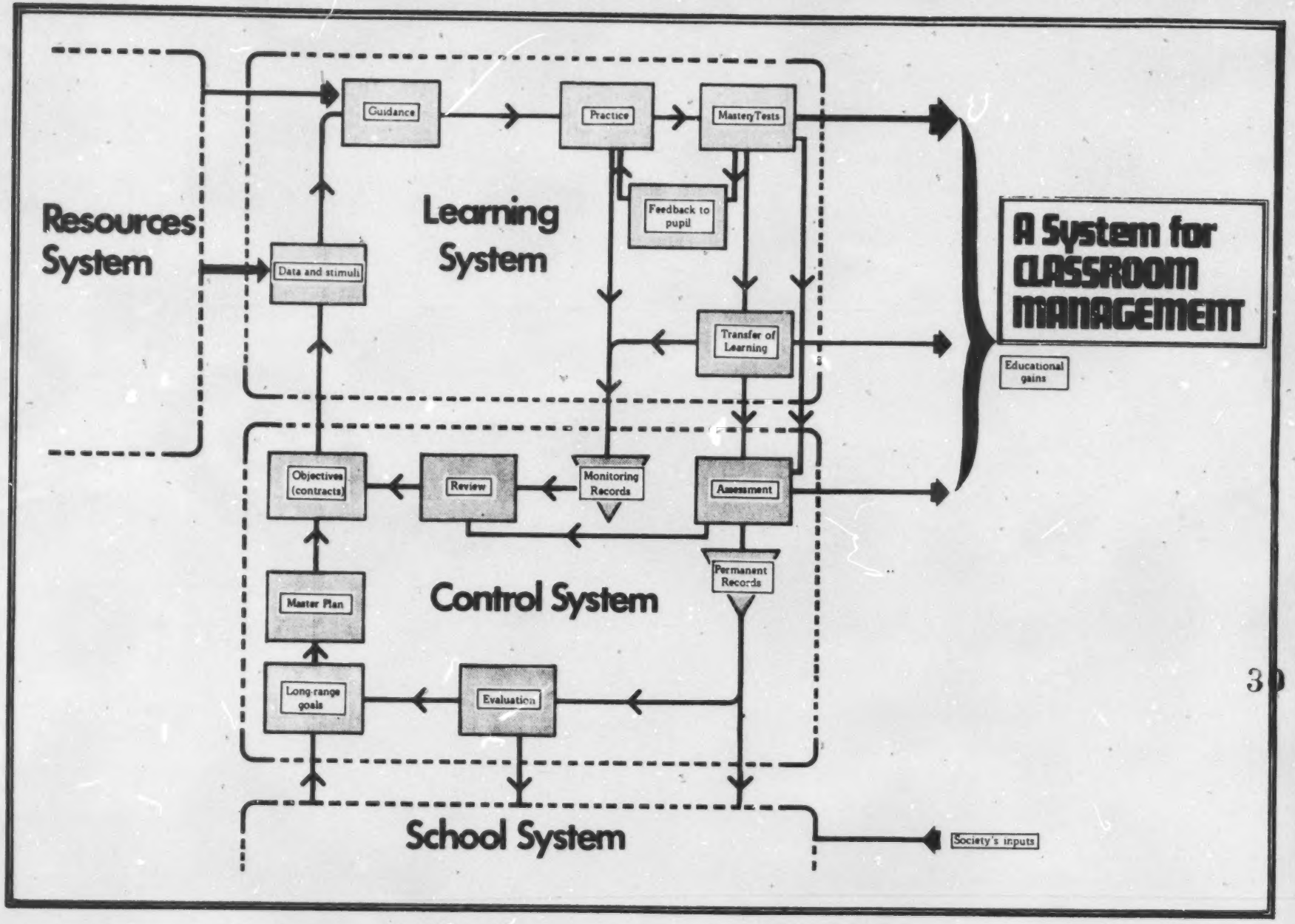
disorderly atmosphere; and the teacher doing two-thirds of the talking.

And wherever two or three teachers are gathered together their talk is invariably of how desperately short they are of resources and time; and how they feel themselves isolated at the end of a long chain of command.

So there is a problem. It is the gap which exists between the sophisticated and visionary thinking of the enthusiasts, and the reality of the Primary and Secondary school classrooms. There is now a grave danger that micro-electronics may not be successfully integrated into classroom work, but will remain peripheral to it, and that for many children in the future school will appear anachronistic.

This danger must be averted, and it seems to me that there is a case for a more systematic look at the technology of teaching, as an essential preliminary to the introduction of the microprocessor into the classroom. We need to invent control systems for teachers who want to organise their pupils' learning on more independent lines. Such systems with their associated tools and techniques, will integrate the various aims, tasks and procedures of the classroom: the record keeping; the guidance procedures; tutoring; assessment procedures; the teacher's objectives; the pupils' choices; the storage, indexing and retrieval of resources. We need to invent or adapt documentation to serve the needs of the classroom. Above all we need to criticise and test our system in terms of teachers' time, which is our most valuable resource. This is not to advocate a prescriptive or mechanistic approach to the problems of the classroom. But the problems and the conflicts of the classroom are now so complex that it seems reasonable to claim that common-sense alone will not yield the best results.

To support the more sophisticated styles of classroom management there must be a more sophisticated development of learning materials. Traditionally our development projects produce ideas and exemplar materials, which is fine as far as it goes. But this leaves far too much of a burden for the teacher, and the history of curriculum development is already littered with the casualities of the implementation stage. The microelectronic revolution demands that we take a new look at curriculum materials. The hardware and software are not the problem; we should be worrying about the "course" ware. The tangible outcomes of a new-style development project might look something like this:-


A System for CLASSROOM MANAGEMENT
Resources System
Learning System
Control System
School System
Guidance
Practice
Mastery Tests
Feedback to pupil
Data and stimuli
Transfer of Learning
Educational gains
Objectives (contracts)
Review
Monitoring Records
Assessment
Permanent Records
Master Plan
Long-range goals
Evaluation
Society's inputs

- a collection of carefully selected data and stimuli together with specially produced material;
- a bank of guidance materials for students, both for individual use and for small-group use;
- an analysis of resources and guidance in terms of objectives, levels of difficulty, possible routes;
- a bank of test items, thoroughly analysed and validated;
- a teacher's guide;
- a purpose-made pupils' contract/record system for the careful monitoring of the progress of individual students.

Such a product would lend itself to the micro-processor and the teacher's efforts made more effective.

There will still be problems: the cost of microcomputers is still high in relation to the budgets of most schools. If the quantity of hardware is to be limited then inevitably there will be conflict about location and use.

MICROPROCESSORS AND MICROELECTRONICS AND THEIR EFFECTS ON PUBLISHING

N. Willis
Assistant Director
Council for Educational Technology

Book publishing, in the eyes of the general public, has always been a "gentlemanly" business; not too commercial, with a product loved and cherished by its purchasers, and sold through quiet and often beautiful shops staffed by helpful assistants (as opposed to salesmen). Whether this view is shared by those who actually work for publishers is best not enquired into too deeply, but it is certainly true to say that anyone entering the publishing business up to the late 1950s would have found himself doing much the same job as his predecessors one hundred years before. Production and sales techniques had altered very little in that time. Indeed, why stop at the 1950s? Even today, very little has actually changed: there are many new production processes, most noticeably in the typesetting, illustration, page make-up and printing departments, but the process of commissioning an author, editing his manuscript, producing the book, "publishing" it, publicising it, managing the warehousing and order fulfilment, all this is basically as it has been ever since there was a publishing business.

So, why talk about it at this conference on the educational implications of microelectronics? Because it is quite a good case-study of what can happen when this new technology impinges on an established business, comfortably settled in a five-hundred-year worn groove.

In discussing the effect microprocessors and microelectronics are likely to have on publishing, I am deliberately going to omit all consideration of fictional and "leisure and pleasure" publishing because I think that (very large) branch of the business will not be greatly affected for a long time to come - if ever. I shall be surprised if our grandchildren's children haven't got books to read, and don't find themselves enjoying the books of today as we did the books of the Victorians. So, to Lesson One: microelectronics will certainly shake the world up - but not all of it, nor all at once.

I want to concentrate our attention on published information: news, reference material, and the whole range of educational and academic publishing, because

this is where the impact will arrive quickly and could bring revolutionary changes.

Let us look first at the technical developments which are either here already or are almost at production stage, and which alter information publishing dramatically: developments which arise from the convergence of work on telecommunications with that on microelectronics.

Public view data systems, of which the Post Office's 'Prestel' is the first in the world, can deliver alphanumeric information plus simple diagrams, in colour into the home as well as into the office or library. The significance of this development lies in the very fact that Prestel is a public system. It is designed to be operated by the general public, with the minimum of barriers and no need for training, through a terminal which appears to the user as an ordinary television set (which he knows has some extra electronics built in) controlled by a simple numeric keypad. So, unlike the existing bibliographic search systems requiring expensive terminals and trained staff for mediation, Prestel offers a relatively cheap, easily understood terminal, and a hierarchical search system designed for anyone to use. Perhaps even more important, Prestel is being set up to deliver facts, not references to other published materials. Its Information Providers are already referring to it as a medium for electronic publishing. It does not demand that the user has access to a 'back-up' service or to printed information held in a library somewhere.

Another important line of development is 'word processing'. This phrase covers systems of widely differing technical complexity, ranging from simple automatic typing devices up to the controversial methods designed for the use of newspapers like The Times, all of them making heavy use of microprocessors and other microelectronic techniques. The essential point about word processing is that the act of typing, correcting and editing text is carried out directly on to a computer storage medium. Therefore, the finalised text can be worked on (classified, indexed, up-dated), read, transmitted to other parts of the world, or archived without ever having to be put into printed form on paper. Although, at present, word processing systems are expensive, much of the cost lies in the peripherals, especially the parts of the system designed to provide hard copy. It is virtually certain that in two or three years a system designed specifically for authors (because businessmen who write commercial documents are also authors) will become available, which will be designed for direct inputting of text, with correcting and editing facilities, and probably, with automatic formatting of the desired text presentation. This will enable copy to be prepared in the

author's own office directly on to a computer storage medium from which it can either be accessed directly, or from which it can be automatically transferred to a computerised database, or automatically printed on to microfiche or paper.

One other development needs mentioning in this connection: the rapid introduction - and falling cost - of microcomputers. Quite powerful equipment (although with limited 'memory') is already available in High Street shops for prices little different from those of domestic television receivers. Their significance lies in their ability to act as 'intelligent terminals' in the home or the office, into which data can be fed rapidly over the telephone line from a distant database, and which could be programmed to permit a variety of forms of interaction with the data once captured. In addition it should be noted that a microcomputer, connected to a 'printer' unit and provided with suitable software, can act as a word processor. So the rapid spread of home computers could easily lead to a very rapid increase in the national availability of word processing and home printing capability.

How will these developments affect publishing. First, let me deal briefly with "news" publishing, even though that is a very different business from the rest of the publishing world. The technology already exists to enable a reporter to file his story, have it "subbed" and headlined, and made available for electronic retrieval without ever being printed. Given the development of a reasonably cheap "home printer" driven either directly from a Prestel receiver or a home microcomputer, a news "briefs" service could be offered over Prestel, with optional articles backing up various news items, ready to be called down to the home printer if required. Such a service could make it possible for the user to have the two articles he wants to read from The Guardian, the film reviews and stock market prices from The Financial Times, a sports report from the Daily Express, and the picture from page three of the Sun. At last, a newspaper to suit the needs of the reader, not the editor.

So far as reference book publishing is concerned, I simply cannot see, once Prestel is nationwide in, say, ten years time, why anyone should bother any more to print most reference books. Railway timetables; restaurant and pub locations; menus and prices; adult evening courses; details of local authority staff: the list could be virtually endless - can be made available through Prestel, and, what is most important, can be permanently up to date. As soon

as a change is notified, the entry on the computer can be changed. Already, in my own office, we have virtually stopped using the printed ABC Rail Guide for Inter-City services from London in favour of the same information on Prestel. It is quicker to use, more up to date, and could save us five or six pounds a year.

Now to academic publishing: the area in which I am myself directly involved. Here again, I see great changes coming, pushed forward by the shortage of money in higher education and the overwhelming flood of scientific and academic verbiage, and made feasible by the conjunction of microelectronic and telecommunications advances.

Let us look at this little scenario, which I should stress is possible now (although more likely in five years' time). We are not talking about science fiction.

Having just completed a piece of work, a university researcher wishes to publish his results, and knows that the professional society to which he belongs has a 'recent research' database (which he often uses as a reference). He types up his results on the word processor keyboard unit which he shares with his secretary and other members of the department. His modest typing ability is helped by ease of correction, and he is able to modify, re-write and re-order the text at will, until he has a version which he thinks adequately represents the results of his research (just as he would with pen and paper, except that at the moment of completion of 'writing' it is fully typed to an agreed format). The word processor diskette containing the completed 'paper' and the author's summary is passed to the university's central communications unit for automatic overnight transmission to the professional society's terminal, which produces a hard copy version and a computer store version. The following day the hard copy version is sent out for refereeing, whilst the computer version is read into a temporary store. As a result of the referees' reports, the author modifies two or three paragraphs of the paper on his word processor which automatically incorporates the revised paragraphs into the original text and the agreed version is again transmitted to the soceity overnight, where next day it is read by the computer straight on to the database where it becomes immediately available to users of the 'recent research' service. The professional society would, whilst refereeing was in progress, have scanned the paper to highlight new facts, and to decide on the key-words to be used in the search procedures. Delays in making

the 'paper' generally available will arise only from the refereeing process.

Now let us look at the same researcher, using the database whilst carrying out his work. When beginning on a new area, a literature search had been carried out for him by the library, which enabled him to become familiar with previous work in the field. But research is moving very fast and it is essential to keep track of new results. His professional society operates a 'recent research' database which accepts, referees and classifies papers not only from the UK but also through arrangements with other societies from European countries and the USA, through international data networks. The society's weekly awareness list of papers added to the database is available through their Prestel pages. The very basic information provided is classified into nine broad categories, and our researcher, knowing precisely the Prestel page number listing new work in his area, can call it up immediately each Monday morning and quickly scan the list. The routing procedure enables him to select the three papers which seem likely to interest him and to call up the short abstracts and the 'new facts' analysis for each paper. Deciding at this stage that there is nothing new that affects his work, he disconnects from the Prestel. If he feels that one of the papers throws new light on his work, or even that he has a hunch the society's 'new facts' analysis may have overlooked an aspect of a piece of work which interests him, he can use the Prestel response procedure to ask for the full text of the paper concerned. This may be sent to him in printed form by post for leisurely perusal, or be sent be telephone directly to a memory store of his microcomputer, where he can read it off-line, but almost immediately. There will be no need for him to keep the text for reference later, since its reference number can be noted so that it can be recalled later from the database if it is needed again.

This scenario is a simple one, which leaves out a number of refinements which are possible, avoids discussion of a good many organisational and technical difficulties and also completely avoids the matter of cost. For readers of this paper, its purpose is to demonstrate that it is feasible for such a system to operate completely without the intervention of a publishing house. There is no requirement in this system for the multiple production of printed copies requiring warehousing, subscription systems, distribution methods, and leading to the purchase by customers of redundant or simply unwanted information.

So, is that the end for the publisher? Has he gone out of business? Not if he has any sense. He will be in one of two categories: the ostrich or the hawk - both well adapted for survival. Some publishers will simply refuse to recognise what is happening - and for twenty or thirty years there will be no noticeable effect on their businesses. Of course, there will not be a total switch away from reliance on monographs and Journals and book-lined studies: after all, even five hundred years after the technology of printing swept the civilised world, there are still some people making a calm and fairly comfortable living writing books by hand in fine calligraphy. I suspect that the publisher who does decide to ignore these developments completely will find, for some time to come, support amongst many academics who themselves will resist the new methods, who will look to 'publication' for recognition, status and promotion, and who will see media other than print as being far inferior in some way. And by the time academics have come to realise that "mere publication is no recommendation", enough time will have passed for the ostrich publisher to have retired - leaving someone else to cope with the twentyfirst century.

How about the hawks - already high up. surveying the scene looking for fresh pickings. They still have a lot to offer. They will see themselves as a seller of information, a source of reputation, and a provider of money for knowledge created.

As a seller of information, the publisher will consider more deeply the needs of the user. The pressures of time, cost, and sheer quantity make the user cry for help in finding what he needs to know quickly, cheaply and easily. The new technologies can make this possible, and the wise publisher (in my view) is the one who is looking for ways of presenting the information content of the material he is handling which will appeal most to the user. He will be talking to learned societies, to database owners, to establish ways of cooperating with them to provide this user information.

Above everyone else, the publisher knows how vital is the contribution to scholarship made by his professional editors. Any direct word-processing input system could lead to a sharp drop in the reputation of some academics for lucidity of prose. The publisher's editorial expertise, on which much of his own house's reputation is built, will be as desperately needed as ever before. He will seek a way of marketing it.

The publisher is a businessman, aware of money, rights and contracts, and well used to the problems of administering the distribution of various shares of the overall income. Academics (at least in the majority of cases) have no expertise in this field. They must therefore look to their publisher to protect their interests, no matter what method of distribution is being used for the knowledge they are creating.

So, it seems to me that, in the face of the new technologies of telecommunications and microelectronics, the publisher has to look for new emphases in his business. His work will move away from the business of making and selling wodges of printed paper, sold in the largest numbers possible at the highest price the market will stand, with warehousing and order-fulfulment, subscription handling and trade discounts looming large in his life. Instead he will become an information and service provider, improving the access to intellectual content, acting as collecting point, communication centre and even sieve for information on its way to databases; being an intellectual property agent perhaps working in partnership with an authors' agent, negotiating access costs to information on behalf of his 'clients', seeking the best outlets, and administering and apportioning the income. And, by the way, ensuring that he is adequately recompensed for his expertise. I can see a great deal for the academic publisher to do in a world of computerised information handling, but he, like many others in this changing world, will have to be aware of the new developments, and prepared to change his ways, radically if need be, to keep on making a profit.

Reports of Discussion Groups

What parts of the school curriculum ought to be most affected by the new technology?

Alan Garnham
Principal Adviser, Avon Education Department

The group followed the suggested pattern of working, individually to begin with, then in twos, fours, and finally the whole group. This report covers the whole group part of the exercise.

There was a clear minority view, expressed at the beginning of the whole group discussion, that the so-called microelectronics revolution was not and would not become part of our social culture, and schools need do very little, if anything, to change their curriculum. The rest of the group had accepted the inevitability of the changes to our living patterns as a result of microelectronics, and the responsibility of the educational system to accept the implications of these changes for the school curriculum.

The group took issue with the wording of the discussion question, in particular the word 'ought'. In the majority view, the new technology will, inevitably, affect all the school curriculum not just parts of it. A consequence of these affects on all aspects of life, in and out of school, is that all educators will need to question why children should continue to go to school, and what should they do there. Aims and objectives would need rethinking in society and in schools. The introduction of microelectronics is seen as having a profound influence on values such as the protestant work ethic. No longer will schools necessarily need to transmit this cultural norm. New skills will be needed for the microelectronics future, and schools must be prepared to train for and transmit these skills. It was suggested that a "service" ethic would replace the work ethic, and attention paid to self-fulfilment and social responsibility. Schools would need to adjust their curriculum accordingly. In other words, schools will soon need to be concerned much more than they are at present with attitude changing. It was suggested that it might be necessary for schools to promote "a gentle luddite action", i.e. an attitude that would provide the necessary humanitarian check to unthinking technological progress.

Concern was expressed at the time needed for such attitude changes and whether the speed of technological advance would allow this. A return to a form of "working man's groups" in adult education may be needed.

In addition to this increased emphasis on the affective schools will need to cater for two distinct groups of pupils, those who will become the technological specialists of the future, and those who will use the technology but not advance its progress. This will, it seems, lead inevitably to a form of elitism. In this context, it was pointed out that what was required was technical awareness rather than technical skill and competence. (Question: How do you get "awareness" other than by practising skills and gaining competence? "I do and I understand".)

Schools must change their methods of teaching to take cognisance of the rapidly changing methods of information transmission now available through microelectronics. To this end, a large in-service provision is essential. Who is going to re-educate the teachers?

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A. Philpot
St. Paul's College, Cheltenham

All parts of the curriculum ought to be affected by the new technology:-

(a) to afford pupils of every ability the opportunity to practise the retrieval of information;

(b) as an additional weapon in the teacher's armoury of methodology, providing for pupils' practice at basic skills and for structured learning;

(c) to provide the opportunity for more able pupils (C.S.E. Grade 3 and above) to practise processing of retrieved information, i.e. sorting and classifying, for example;

(d) to make pupils aware that they will experience many changes during their lives and create a willingness to adapt.

Basic skills in the use of keyboards should be taught. There should, however, be no attempt to teach the theory or practice of computing in general as a separate discipline on the time-table. Pupils should be encouraged to use

the new technology in as wide a classroom context as possible. If schools were to afford pupils some simple training in programming, employers suspect that it would help provide them with recruits who could think more logically. However, the new technology is unlikely to affect the hidden curriculum, about the results of which employers complain in respect of recruits' attitudes to work.

If teachers themselves were also obliged to learn some simple programming and a systems approach, it would help them to be more logical about the basis for their curriculum.

Teachers would then have to decide what level of hardware was necessary. It may be that it is not so sophisticated as presently imagined and that (at current prices) some £400 would suffice. A microprocessor in ignorant hands is a waste of money. There is a pressing need for the exchange of ideas and software. It may be that we can all learn from authorities with major experiments underway - such as Birmingham.

Why should the introduction of the new technology affect the overall number of jobs at all? As one member of the group put it, "unless we exterminate people, we have got to pay for them anyway." We might as well pay for them in service work as on the dole. Many of these service jobs do not yet exist; nor can we guess at what they might be. It is likely that the satisfying use of leisure time will become more important.

However, the country will need an elite of scientists and engineers. They will need to be separately educated in schools. If there continues to be a shortage of teacher time, perhaps people from industry could be brought in to do special work with this group.

How should education equip learners for a society in which full employment is not an axiom?

Roger West
Managing Director, Probe Engineering Company Limited

While the opportunity to discuss this subject was appreciated by members of the group there was some criticism of such a vast brief!

Many general opinions were expressed during the discussion. Some people felt that there was an innate arrogance in the whole idea of equipping people for their leisure time - a 'big brother' conceit. Others felt that schools were being called upon by society to do a job they are not equipped to do. Others again that we need to see education as a continuing process, certainly not finishing the day we leave school. Facilities should continue to be available to all age groups to return to education. Provision should be made for grants to be available.

More specifically there were suggestions that political education might be of central importance in equipping people for the future. This should take place at every level so that people would be aware of the structures of society and of the possibility of choice within it.

Another approach was to ask what people required above all else from the society they live in. It was agreed that recognition and fulfilment, generally found at work, answered this question. This led to some debate about the possibility of breaking down on present very large schools into small units where pupils and teachers could form a genuine almost self-sufficient small community. They might grow their own food, cook their own lunch and learn to take responsibility and make decisions. In such a community mutual respect might grow and the person be recognised. The quality of life would be very important in preparing the future adult for a life where the pace of things would be slackened and the quantity of things reduced. Also agreement on the importance of skills in personal relationships and the building up of a more 'caring' community.

Objections to such views were expressed. Early selection of talented

children would be essential to establish an elite core to preserve our international competitiveness.

Fears were expressed on this point such that such an elite would do little to reduce conflict within society.

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Professor W.H. Dowdeswell
Chairman, Frontier Group

At the outset the group rejected the idea that high unemployment resulting from the microprocessor revolution was necessarily axiomatic. There was a danger that prophecies of this kind could become self-fulfilling and this was a trap to be avoided. There was no doubt that the kind of jobs available in the future would change and this could be something to be welcomed. The present idea of a job for life would almost certainly have to go and individuals at all levels of society must expect retraining perhaps several times during their lifetime. The group also felt that the rate of change could be overstressed. In business this is ultimately governed by two limiting factors - cash and on-the-spot resources. If these are in short supply (as at present) changes could take place far more slowly than is sometimes suggested.

Other points emerging were:

(i) in an educational context, technology is essentially an attitude of mind and the word tends to be used in a far too restricted context. Thus we have the technology of education and the technology of reason (philosophy). We are all technologists by background. Technology is not just applied physics and mathematics.

(ii) in technological occupations, repetitiveness is not necessarily objectionable. Many people liked an element of repetition, not just the least able. The important consideration is the social context in which repetitive work takes place. The difficulty here is that when retraining is necessary, the least able are the least flexible and

exhibit the greatest polarisation of attitudes.

(iii) other forms of education for the future must include potential leisure activities (but not presented as "leisure") such as music, art and photography. The aim should be to make school leavers as self-sufficient as possible.

(iv) another important aspect of education for the future is teaching children how to use educational facilities and the inculcation of the idea that learning is not just confined to school. To this end more relevance to the outside world needs to be introduced into the school curriculum e.g. project work concerned with the local community such as the implications of new building and road-making. This is particularly important for the less able who can respond enthusiastically to such work.

(v) teachers themselves need to change, particularly in their attitudes to their profession. Thus they should regard themselves as agents of teaching technology (i.e. catalysts of learning) not experts on content.

(vi) a hopeful sign for the future is that we seem to be moving towards a more normative forecasting of goals, rather than basing our predictions on the past. Until about 1970 there were signs that technology was controlling society. Now there is evidence that the reverse may be taking place.

Methods of Learning - the potential of microprocessors for independent and interactive learning

N.D.C. Harris
Director, Science and Technology Education Centre
University of Bath

and

B. Barnett
Training Manager, Avon Rubber Company

Microelectronic devices, such as microcomputers can be used at three levels. The first level relates to remedial and developmental work aimed in particular at children moving from one area to another. The second level is aimed at fact gathering, for example with junior school children classifying facts and figures which can be retrieved when needed. The third level is aimed at decision making and values through simulation exercises. This third level may be sophisticated game simulations at the sixth form level or real problems at lower levels. The group concentrated on the effects of microcomputers on methods of learning.

The problem is that at present it is unlikely that more than one microcomputer will be available in any one school. In this situation the microcomputer will become a demonstration device having little effect on methods of learning. Two alternative strategies would be to have either a central room of microcomputers in an authority to which classes are invited or a mobile caravan with microcomputers lent to schools for a week or more. In either case advice and assistance on inservice education would be necessary for teachers wishing to use the microcomputers. Teachers would be encouraged to write and to get children to write their own materials for the computer. The main problem is not teachers having ideas, but the time needed to write programmes. It may be necessary for authorities to have software writers available to help teachers.

The role of computers to assist and enhance routing, planning and assessing learners work has been shown to be feasible in the National Development Plan in Computer Assisted Learning. The cheaper and more accessible computers are now available to implement these ideas. The purchase of the computers is

a problem to Local Education Authorities in the present economic climate. Perhaps Industry and LEA's can cooperate not only in this field but also in program writers too.

Program writing will tend to occupy a large proportion of the time of the school microcomputers unless second terminals or microcomputers related to main frame computers are made available. The problem on introduction will probably be analogous to a printing facility in a school when introduced: too many users. A contrary point of view suggested an analogy with a 16mm projector, where most teachers are unwilling to use the equipment. Children may well be more familiar with microcomputers than teachers, in fact home computers may have as much power as school computers. (The possibility of home computers linked to a central main computer for homework, testing and examining was mentioned.)

The problem will be teachers fighting against children using the facilities in a similar way to calculators. Children will see the equipment merely as a tool.

Untold time savings could be made at the comprehensive/secondary schools level if pupils were taught to use electronic devices early, say in the 8-11 age range, leaving extra time for teaching life skills or higher technology which would be more appropriate to the style of social environment we envisage in the future. By introducing this technology early, the education system may be in a better position to change and influence the attitudes of girls to the engineering profession.

The delay in introduction and the likely effects on methods of learning will cause an enlargement of the gap between the real world and school. The commercial world will teach more about technology and computers than parents or teachers.

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Philip Waterhouse
Director, Avon Resources for Learning and Development Unit

Having divided and finally regrouped in the manner recommended to the Chairman, the following is a report on the answer to the question "What are the most interesting things which microprocessors could bring to schools?

Enhanced opportunities for self-directed learning for the student and the student with his parent, the sharing in the learning process at home.

Care to be taken not to curtail the experience of the child - in other words, too tight programmed learning should be avoided as this could lead to mass self-directed learning.

The implications for teachers were considerable especially in the production of software either simple locally produced or nationally produced material.

The microprocessors could produce a limited model of "Mastermind" reproducing factual information. This fear was an expression of the difficulty in producing a program for the microprocessor which had a capacity for analysing factual information. Both children and teachers would need to write the programs with the wider availability of information.

What is the time scale? How soon?

The chips are cheap but the packages expensive.

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Mr. P. Waterhouse, Director, Avon Resources for Learning and Development Unit
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STRATEGIES FOR CHANGE IN A TECHNOLOGICAL SOCIETY FRONTIER GROUP

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would like forther details on the items listed below:

Frontier Group: Strategies for Change in a Technological Society

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Publications (please enter from list on page)

The activities of the following SATRO's:

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Science Technology and Craft Centre, Gloucester

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My organisation would be willing to assist with the finance of activities organised by the Frontier Group Yes/No/ Require further discussion